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Collaborative Learning Aspects in VSE

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The paper would suggest a pedagogical model for modelling Virtual Scientific Experiments (VSE) starting from the Theory of Didactics Situations and taking advantages from the recent studies on collaborative learning. The possibilities given by the new technologies, and in particular by the GRID, seems to be particulary interesting for the sharing of complex applications such as VSE.

Keywords: learning process, VSE, learning Grid.

1. INTRODUCTION

In the last years the attention for the learning methodologies has produced a shift from simply transmitting the knowledge to actually building knowledge (Vrasidas, Charalambos, 2000). The active involvement, the reciprocal collaboration among the learners, the concrete experimentation in the learning process are become the main features to consider in a learning process (Merrill, 2001). In fact the learning is facilitated when learners is actively engaged in solving real-world problems and actives his/her existing knowledge[1] as a foundation for new knowledge. Furthermore the learning has an improvement when the learners compare their comprehension and negotiate and validate it, through a ideas change.
When the student engages him/herself in active, constructive, intentional, authentic and cooperative learning he/she achieve a meaningful learning. The activity is necessary but not sufficient, it is essential that the learners reflect on their activity and observations, in order to construct their own simple mental models, which become increasingly exact. The learning has to be intentional because the learners learn more when they are fulfilling an intention. The learning has to be authentic because, as shown from many researches, the learning process is more effective when the learning tasks are situated in real contexts or simulated in some case/problem based learning environment. . The learning has to allow the collaboration among the students because during the collaboration they can analyze in critical way and negotiate their ideas, compare among them the understood concepts, validate their insights and propose other more complex investigations. Finally the meaningful learning is a combination of active, constructive, intentional, authentic and collaborative learning (Jonassen et al., 1999).
In this work we want to investigate a possible didactic model for VSE starting from the Brousseau Theory of Didactic Situation suitably modified taking into account collaborative learning features.

2. THEORETICAL FRAMEWORK

2.1. Theory of Didactic Situations

In accordance with the Theory of Situations by Brousseau (1997), which is a clear constructivist learning theory, the learning processes occur within a series of “situations” where, in each situation, three distinct subjects interact: the learner, the teacher, the knowledge, and these are immersed and influenced by the “milieu”. The learning is therefore produced in an active way, personally by the pupil, through the interaction between the above said subjects and the milieu, in situations opportunely arranged by the teacher.
In particular Brousseau refers to a-didactic situations in which attention is paid on the students and the knowledge object, not on the teacher. There are no didactic constraints, therefore what the pupil does is not linked to any pressure by the teacher, and modifies his knowledge system owing to the adaptations that he creates having recourse to the various strategies. These situations take place into the constructivist context (D’Amore, 1999), which puts the student at the centre of its attention while gives the teacher only the task of watching.

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[1] The word knowledge, used by Merrill, is the broadest connotation to include both knowledge and skill, and to represent the knowledge and skill to be taught as well as the knowledge and skill acquired by the learner.

In accordance with the Theory of the Didactic Situations of Brousseau, we need to make reference not to a generic situation but to various types of it according to the kind of relation that may exist between a student and the environment (milieu). So, we can consider the following different typologies of situation:

- Situations of Action: are those in which the student interacts with the environment, «If the exchange of information is not necessary for obtaining a decision, if the students share the same information about the milieu, the "action" is dominant.» (Brousseau, 1997). The sequence of situations of action constitutes the process through which the learner constructs strategies, namely "teaches to himself/herself how to solve the problem (Brousseau, 1997). In this sense Brousseau talks of "dialectic of action" since the student on one hand can anticipate the result of his choices and on the other hand the chosen strategies can be confirmed or not by the experimentation/interaction with the environment. The situations of action promote in the student the rising of a "model", namely of a representation of the situation, which may be more or less implicit. On the basis of the model the student little by little constructs, he will do his following choices.
- Situations of Formulation: are those in which the student sends messages to the antagonist milieu with the intention of presenting an opinion (Brousseau, 1997). When the strategies are formulated, there are two strategies of feedback: one to the environment (milieu) that, once the formulated strategy has been applied, gives a response which can be positive or not; one to the other students he interacts with, who say if they have understood. The situations of formulation encourage the acquisition of explicit models and languages; if they have an explicit social dimension, we can talk of situations of communication (D'Amore, 1999).
- Situations of validation: are the situations in which the messages exchanged with the milieu consist in assertions, theorems, demonstrations, both sent and received, namely the affirmations must be subjected to the judgement of the interlocutor who must be able to give a feedback, to protest, to reject a reasoning, to express some counter-examples, etc. therefore there must be an a priori symmetric situation, since a discussion between teacher and student is not advantageous. These situations have to lead the student to evolve and revise his opinion, replace false theories with true ones, to organise the demonstrations. We point out that the students must be brought to discover their mistakes, these activity results to be fundamental for the construction of the knowledge.

2.2. Collaborative Learning

The collaborative learning is a process according to which emphasis is given, within a group, to the collective engagement of students and teachers. Here students acts as a "community of learners" (Ligorio, 1996), and knowledge arises from the comparison of their own thoughts with the whole community, finalized to the attainment of new abilities and competences through the sharing of information and knowledge (Hiltz 1988).
The collaborative learning is also a democratic process, in which all the participants are equal and are treated like that, playing a role that is valued by everyone of them. It is based on great responsibility of the single individual towards the group or because the task foresees an explanation or because the communication between actors is finalized to the production of a common paper or to the solution of a common problem.
Vygotsky has shown that every individual has two different level of "skill", one represents all things that he/she is able to make without help of someone (effective development), the other one refers to the competences that he/she is able to make if he/she is supported by an expert or simply a peer, confronting his/her ideas with him/her (potential development). The distance between the two representations is the "proximal development zone", it is the improvement that the learner is able to achieve if he/she collaborates with other colleagues or if he/she is supported by an expert/teacher (scaffolding). The contact with the peers allows the learner to operate in his/her proximal development zone, achieving advanced results that he/she alone is not able to obtain. So, collaborative learning assumes very much importance and allows to obtain more advanced results through the interaction with peers.

2.3. Strategies for collaboration

Diaper and Sanger (1993) proposed the strategies classification of the collaborative work, distinguishing them according to the execution modality and characterizing so three specific categories: parallel strategies, sequential strategies and reciprocity strategies. They represent a progressive shifting from cooperative to collaborative learning, according to the Hooper's definition (1992).
Thought these strategies are not mutually incompatible and, according to the circumstances and the requirements, the collaborative work can adopt one or more strategies (Trentin, 1996).

Parallel strategy

The parallel strategy is a collaborative approach in which the total product is decomposed and shared among the various members of the group, giving everyone of them the possibility to work with sufficient autonomy. Each member of the group works in autonomy on a specific part of the total product.
In this strategy, some phases of the production can be conducted simultaneously and each group member must have care to update the other participants regarding the state of its script to fixed deadlines, sending directly or putting it at disposal in a common working area (for example a net server). Generally the integration of the various parts is assigned to a member of the group or a subgroup with functions of "editor".

The parallel strategy is particularly recommended when the total task is easily decomposable in segments but not too much interdependent. It guarantees to the members of the group the greater degree of mutual independence. The communication is mainly finalized to the discussion around the work structuring and the modalities of produced modules resetting: the interaction is also functional to the standardization of the individual productions.

Sequential strategy

The sequential strategy is an approach based on the subdivision of the total activity in stage. The product of each stage is assumed as departure line (as income resource) for following stage. Each member of the group, in turns, acts on the semi finished product bringing his/her own contribution.

This proceeding way could have as critical point the implicit conditioning that derives operating on a product which, in some way, is already characterized by those who have manipulated it in the previous stage. Even if the contents and methods are defined a priori and agreed in details among the various members of the group, in the moment in which the single one is requested to taking part on the semi finished product, unavoidably connotes it with his own formulation and style. This can affect the participation of the next colleague and have other repercussions, i.e. it risks also provoking sensitive deviations between the initial detailed purposes and the final result.

In the sequential strategy the interaction frequency is higher, because who inherits part of the work has the necessity to obtain explanations and advices from who had preceded him, and beyond that, to supply useful indications to who will replace him in the following phases.

Reciprocity strategy

The reciprocity strategy is a collaborative approach in which the members of the work group are in strong interdependence in every part of the total product. Each member of the group must constantly regulate his activities in order to adapt them to the production of the hoped conclusive objective.

This strategy can be activated making reference to a basic version of the product, visible by all (for example by being registered to a central server), continuously updated, on which everyone can take part with his own integrations or reviews.

Obviously, this implies an adapted allocation of the tasks (who works, on which part of the work and when) in order to facilitate the assemblage of the single members' activities and the integration of their contributions. It is decisive also to establish the criteria to select the various modifications or reviews when there are several concomitant proposals (more individuals could propose different modifications at a same part of the product, in phase of development).

The reciprocity strategy demands the most elevated interaction frequency, because, due to its nature, it demands a remarkable degree of synchronism between the participants and a remarkable ability of quickly debating and resolving possible controversies and divergences with respect to the realization of the assigned task.

3. VIRTUAL SCIENTIFIC EXPERIMENTS

In this section we want to model Virtual Scientific Experiments starting from the various Brousseau's situations and considering them as collaborative activity, that is as a process in which each member of the group works on every part of the total task. Sequential and reciprocity strategies can be applied in the development of an VSE.

In the following figure we describe the VSE model using IMS Learning Design, so an VSE can be seen as a workflow of activities, and for each of them we will define roles, services and activity.

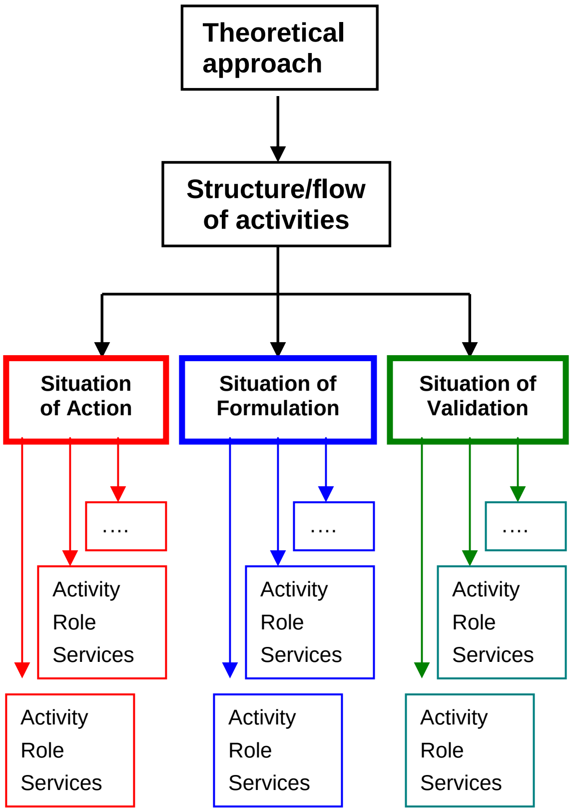

FIGURE 1: IMS Learning Design for VSE model

At first students are engaged in situations where the learner has to interact in active way with the milieu and he/she is not a passive receptor of the traditional learning. The student can be immerse in a "real" motivating and involving context, which foreseen some active phases and choices made and personally managed by the student, to whom the milieu replies. Such situations can be realised for example through more or less complex simulations, virtual 3D environments, microworlds, etc, properly arranged by the author/tutor. Here the milieu acts as a black-box: the students changes some parameters and observes how the environment modifies accordingly. According to such considerations and looking at the attributes of meaningful learning, individuated by Jonassen (1999), the situations of action can be realised environment having the following characteristics :

- "active" to allow the students to manipolate, even if virtually, objects able to react to the action performed by the learner;
- "meaningful" that is the learner has to be engaged in meaningful task so that they can effectively manipulate objects and observe the results of their manipulations: e.g. not just move a cursor or press a button, but modify parameters, shape, viewpoint, and so on;
- "dynamic" in order to change themselves on-the-fly according to the actions performed by the learner.

Considering the reactions of the environment to their manipulations, the learners construct in their mind some conjectures about which are the relevant aspects of the experience, about the relation cause-effect in that particular context. Seeing which are the parameters modifying the experience they hypothesise some beginning (sometimes superficial) relations among them, so they are able to predict the effect of some actions.
Here we can individuate a cycle with three main steps (Tall, 1995): perception of an object (external activity), corresponding to the concrete experience of the Kolb model; thought (internal process), corresponding to the reflective phase of the Kolb model, in which the learner reviews what has been done and experienced, and action (external activity), where the "thought" of the learner is translated it into predictions about what is likely to happen next (that is planning in Kolb model).
In Brousseau's theory such action is individual. It can be remain using a collaborative parallel strategy where each student makes his/her own action on the milieu, observes the reactions, produces conjectures and later they share with other students. Nevertheless it is well known that the collaborative work produces the definition of deeper and critical strategies. Students learn best when they are actively involved in the process. Researchers report that, regardless of the subject matter, students working in small groups tend to learn more of what is taught and retain it longer than when the same content is presented in other instructional formats. Students who work in collaborative groups also appear more satisfied with their classes. Then the situation of action itself can be shared, in the sense of using contemporarily the same milieu where each learner is free to make his/her own actions which are now visible to any other co-learner. If the environment can be contemporary managed by a group of students, each member of the group can act, reflect, comment on the basis of the performance of his own and of any other colleague. In such a way we have a super-additive value the different points of view (or mind) of the co-learners engaged imply different actions to be performed and then different reactions of the milieu. We can say that the

learner has at his/her disposal not just various perspectives of a phenomenon, but different minds stimulating his/her own reasoning.
In realising such shared complex environment GRID will be very useful because they represent a suitable technological infrastructure able to support such process allowing to each learner to use and share, in a transparent and shared manner, all the resources already existing on-line.

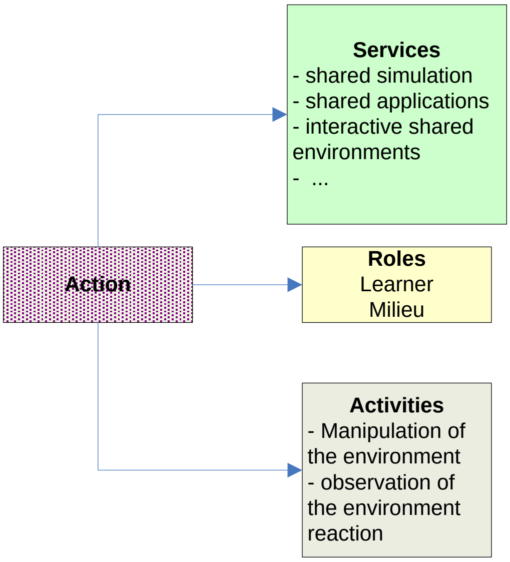

FIGURE 2: definition of a situation of action in terms of Services, Roles and Activities

Once conjectures arise in their mind, learners are ready to formulate their hypotheses. Students are required to make explicit their own model of the experience, that is the implicit model that he/she has built “acting”, for example he/she is asked to make explicit the relations intervening among the variables at stake, to write a formula, to realise an algorithm, etc. They are able not only to predict but now they must have the chance to test their own model, in order to clarify it. Thus we can say that the student also approaches an enactive proof: «In enactive mode proof is by prediction and physical experiment» (Tall, 1995). They can also interact with the shared environment as above, but here the milieu acts as an open environment, that is it replies by applying the received model and the student has the possibility to understand if the supposed model produces coherent results or not. This is the phase where the student, after the perception of and the interaction with external objects, starts to construct his own visuo-spatial prototypes becoming successively more verbal-deductive, leading to iconic or visual proofs, representing not only a specific case but all the cases in a same class.

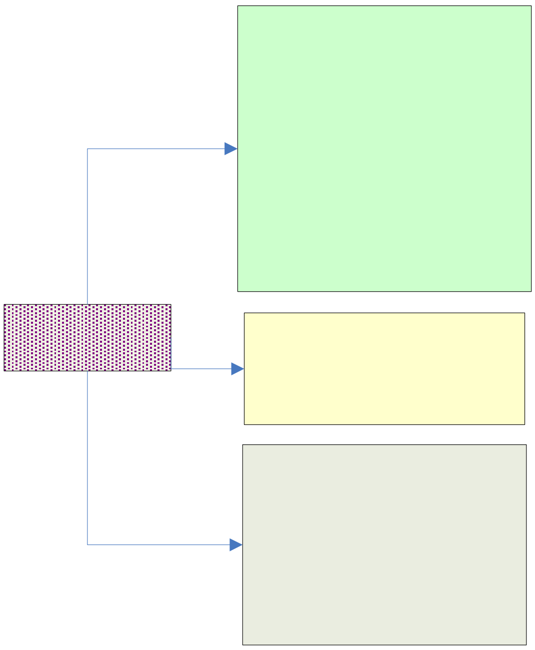

FIGURE 3: definition of a situation of action in terms of Services, Roles and Activities

Since learning is a social construction, it is opportune that these situations are in particular situations of communication: the explicit models of each student can be shared and discussed with other students during virtual debates, forecasting a confrontation, in a collaborative learning process, through tools (synchronous and asynchronous) specific for the communication, the sharing of the resources, to support group processes (chat, videoconference, shared work on the same files). Working in groups, explaining and discussing with others about the observations as consequence of the actions, allow the student to become aware of what he/she discovers and moreover when the learner has to talk, discuss and illustrate his/her ideas to the colleagues, he/she induces a cognitive process, that improves his/her understanding of topics and develops higher reasoning strategies (Johnson & Johnson, 1986). During the interactions, the learners find many opportunities to reflect upon and reply to the various answers that fellow students get to the raised questions. When questions raise, different students have a variety of responses. Each of these can help the group to create a product that reflects a wide range of perspectives and thus it is more complete and comprehensive. In the comparison, the students add their perspectives to an issue; this exchange helps inevitably students to better understand other ideas and points of view. In this way the interaction among the students increases the mastery of some critic concepts (Vygotsky, 1978 Murray, 1982; Damon, 1984).

Finally situations of validation are collaborative for their own nature. Here students are asked to collect their thoughts, refine all previous idea and present not just his/her point of view but he/she is required to defend it, to give some kind of proofs of his/her statement. The final aim should be to produce a common model together with its suitable justification, that will constitute the knowing. As support a virtual area can be organised (such as a discussion forum) asking the student to produce and share a document with his models and proofs. The debate with other students is considered essential: each student has to "contest" the proofs given by the others and defend his own theses.
As pointed out in (Holey, Noss, 2003), since most of the students interacting with digital technologies spontaneously articulate justifications of their actions along with explanations of why their actions produces the expected feedback (or not), such technologies might give the opportunity to produce a deep understanding of the topic.

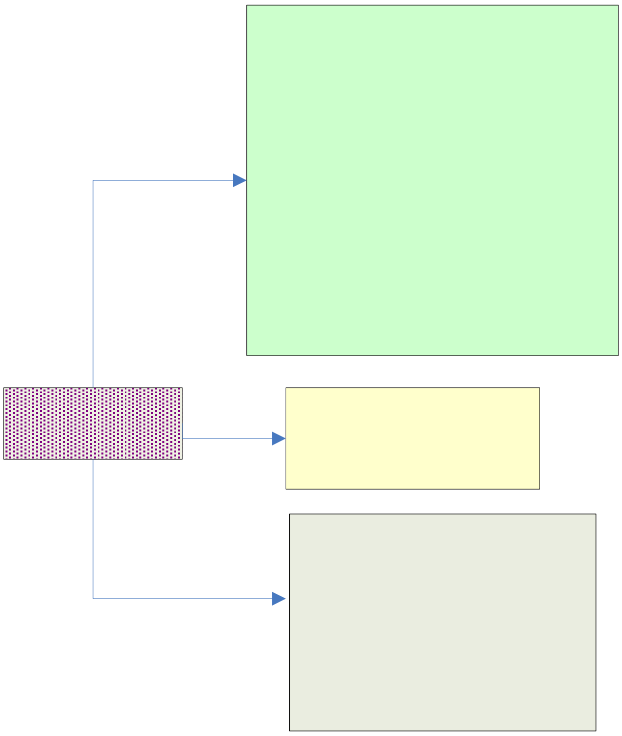

FIGURE 4: definition of a situation of action in terms of Services, Roles and Activities

4. CONCLUSIONS

This paper discusses a possible model for VSE. The situations of action, formulation and validation have been studied and referred to VSE. Besides the experiential approach, the generalisation of those situation to collaborative learning has been investigated. A first attempt to describe the model by Education Modelling Language has been proposed, considering activity, role, service (IMS Learning Design). Grid technologies seem to better support it.

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